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ZOOLOGY

IN THE

UNIVERSITY OF TOKIO,

BY

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Less than ten years have sufficed to build up in Japan an educational institution that may fairly be called an embryo university. Japanese scholars point with pride to the rapid development of Tokio Daigaku as an evidence of the healthful change that has just dawned in this empire; and Western nations have looked on with admiration and surprise at the rapidity and character of the achievement. It is the avowed purpose of the heads of this institution and the Educational Department, to expand and so improve the courses of instruction that "the standard of scholarship attained in it may equal that of the universities of Western countries." This is certainly a laudable aspiration, and one that foreign as well as native scholars would rejoice to see realized. But whoever thinks that it will be accomplished in five years, or in ten, or in any period of time less than half a century, builds his expectation on conceit, ignorance, or both. The difficulties are many and great, and to surmount them will be a task scarcely less arduous than to carry Fuji to the sea.

Foreign toad-eaters—who do figuratively what some of the Japanese do literally—have shown great zeal in their endeavor to blind the Japanese to the difficulties which they have to encounter, and to convince them and the rest of the world that their intellectual superiority has already placed them near the goal of their ambition. It is the conviction of the writer, which he shares with many others, that Japan has suffered far more from the fulsome adulation of professed friends than from the criticism of enemies. It tickles the vanity of a people to be told that they can accomplish in a day what has cost centuries of hard labor in other countries; but let us hope that the Japanese will not lay that flattering unction to their souls.

In one respect Japan has a peculiar advantage; she is in a position to profit, if she will, by the experience of the West. But the idea that the cream of Western civilization can be swallowed at one gulp, and assimilated without digestion, is as absurd as it is pernicious. No spasmodic efforts will ever place Japan on the educational plane of Europe or America; and even a distant approximation to such a condition will require many years of persistent exertion. So perfectly evident is all this that the mere statement of it almost seems like an insult to the common sense of the reader who is familiar with the latest phases of the educational movement in Japan. My only apology for it is the fact that the whole course of events now taking place here, gives most indubitable evidence of a wide-spread hallucination in regard to the most essential elements of the problem. The time is perhaps not far off when the educational interests of this country will fall more into the hands of those who have had the advantages of an education abroad. Before that happens, there will be little room to expect that either the nature and

magnitude of the problem, or the difficulties in the way of its solution, will be correctly estimated and successfully encountered. Meanwhile the friends of Tokio University have to fear that retrogressive measures may be set on foot which will cripple it, at least temporarily, and, possibly, render nugatory much that has been successfully begun.

The writer is in fullest sympathy with the earnest desire of Japanese scholars to see their university rise to the position of an influential center of learning; for he fully believes that the future welfare of Japan will depend very largely on the advantages she will be able to offer her people in the way of education. He is even sanguine enough to believe that this aspiration, under tolerably favorable conditions, would not be beyond the possibility, nor even the probability, of realization. But it is not easy to shut ones eyes to the difficulties of the situation; nor is it the part of wisdom, or of friendly interest, to ignore them because we deplore their existence.

The present financial condition of the country, desperate as it is, is by no means the only source of danger to the University. With the abolition of the feudal system, Japan passed into a transitional period characterized by instability. The love of change and the fickleness now displayed in such striking contrast with the conservative course of her past history, are perhaps more largely the fault of the times than of the Japanese people. In this very fickleness lies at once a hope and a danger; a hope that aimless change may be converted into steady progress, a danger that change will be mistaken for progress.

Among the most serious impediments to progress may be mentioned the baneful influence of caste, which

has survived the overthrow of the feudal system, and still has vitality enough to work immense mischief. That this great enemy of all reform should be allowed to establish herself at the intellectual fountain of Japan, where she can pollute the very source of the chief currents of progress, is perhaps no more than might have might have been anticipated. But there is some room to hope that Merit will gradually win her way, and ultimately assert her rightful authority in defiance of all the shallow pretences of fictitious Rank. Meanwhile the young men of this University may have to witness many disgraceful exhibitions of the tyrannical temper of Caste, obstinately refusing to recognize anything but her own stamp. She may carry her unlawful pretensions to the extremity of attempting to force her stamp even upon the scientific productions of the University. The moment she does this she trespasses beyond the limits of forbearance, and deserves a drubbing rebuke for the insolence. Any attempt to appropriate the property of the scientific world by disfiguring it with the stamp of rank, or by withholding the right of publishing, should be branded as a piece of high-handed robbery, which can never be forgiven or forgotten. It will not perhaps be indulging too far in general remarks, to allude to one more impediment, scarcely less abnoxious than the one just mentioned. This is the ponderous system of official machinery, which has grown to such unwieldy dimensions, that it interferes in a most serious manner with the dispatch of business. It is like an enormous parasite, which weakens the vital pulses, but spares the life of its host in order to prolong its own unprofitable existence. What a happy prospect for this University, could it look forward to a day of deliverance from this incubus which now paralyzes its energies!

It would perhaps be too great a digression to extend further, remarks of the above general character; but it will probably be admitted that those thus far made are not entirely foreign to the more special considerations which are to follow, concerning the course of study in Biology.

The chief aim of the author is to present some of the claims of Zoölogy to a more liberal treatment than it has been receiving from the educational authorities. The time has now come when this can be done without raising the offensive suspicion that he is advocating a cause with the hope of profiting in its success.

There is one danger, however, that, in his desire to set forth facts in their true light, and to avoid even the remotest approach to that path of encomium which has become such a well-beaten track in Japan, and which has acquired a stench quite as offensive as that which pollutes the air of this city, some remarks may take such a pointed turn as to awaken an unjust suspicion, that they were prompted more by a desire to expose, than to mend weaknesses. To any who may find their susceptibilities too thin-skinned to bear wholesome criticism with equanimity, we would recommend a single consideration; namely, that exposure is a first and an indispensable step to mending, and therefore a thing to be desired. Should any one be able to say of this article, that it has succeeded in calling attention to a single weakness not hitherto sufficiently noticed, even though it should not have the additional merit of pointing out any method of removal, the author would have no cause to complain that he had written in vain.

The history of Zoölogy in Japan can not be said to have made more than a respectable beginning. In every branch of Biology, as indeed in other sciences,

Japan has remained a veritable cipher up to the present epoch of her history. That she has thus far failed to make a single contribution to our biological knowledge worthy of mention, is of course a matter for regret; but it is not to be put down entirely to the discredit of Japanese intellect. It is simply a repetition of the history of Europe, with the single difference, that the period of inactivity with respect to science, has been prolonged a few centuries later. The comparatively tardy awakening of Japan requires for its explanation no assumption of intellectual inferiority, since it may be accounted for on other and wholly different grounds. But having made a beginning, and having proclaimed her resolve to enter the race with Western nations, her swiftness will henceforth come into direct comparison with that of every other competitor for the honors of the course. The mettle of Japan is now to be tested; her muscle and nerve are to be tried by new standards; her intellect will be weighed, her progress measured, and her conduct and bearing scrutinized by unsparing critics. To win even the lowest honors will cost money and unremitting exertion. The world stands ready to applaud every well-earned success, and equally ready to show its contempt for all failures arising from lack of energy or weakness of purpose. If the spirit of the Samurai has survived the loss of his swords, if his ambition is made of more worthy stuff than mere love of display, if his intellect has the edge and the ring of the discarded steel, then there will be no halting between the two alternatives of success and failure.

The disadvantages of the situation in which the Japanese student of science finds himself to-day, are not of such a character as to rob his efforts of all prospect of success. So far as the starting point is concerned, his position is the same as that of the student

in any other part of the world. All are at liberty to build upon what has already been done. It is true, Japan has no scientific literature of her own; and her students, in order to bring their productions to the notice of scientific men, will be compelled to make use of a foreign language. But in this particular they are no worse off than the Russian investigators, some of whom are now reckoned among the foremost men of science. As to instruments of research, and libraries, the condition of the student, though far from being the best, is by no means the worst. Evils of this nature are in no sense of the word peculiar to Japan; their remedy is simple and the same the world over. The temporary disadvantages arising from them are certainly great, but not so great that they need prevent the undertaking of scientific investigation.

With regard to functional capacity, it is evident that this University is, at present, inferior in every particular to the best universities of Europe, and quite unequal to the task it is expected to accomplish. Still, all things considered, it has attained a very creditable degree of efficiency, and offers advantages that are not to be despised. If the instruction now offered in the University, both in amplitude and proficiency, can claim nothing like equality with the more celebrated universities of the West, it may still be safely said that the opportunities here given do not fall below the average in some other countries now doing respectable scientific work. The privilege at present enjoyed by the Japanese student, who distinguishes himself in his own university, of completing his education abroad at the expense of the government, certainly compensates for any lack of opportunity experienced here. In one particular the Japanese student of Biology has an important advantage over his European competitor. Here the field for

investigation is in many respects entirely new; whereas in Europe the most available ground has been preoccupied.

There are still other important natural advantages to be pointed out further on. Taking all sides of the question into consideration, it is certainly no exaggeration to say that the position of the student here compares favorably with that of students in other countries.

The point here to be emphasized is this: The *will* and the *ability* of the student must be measured, here as elsewhere, by the quantity and the quality of his scientific productions. Stated in more general terms, the intellectual ability of Japan is to be estimated by what she accomplishes in the various fields of scientific research.

The object of the foregoing remarks—if it need be stated—is two-fold; first, to show how premature are many of the statements which have been made in regard to the caliber of the Japanese intellect; secondly, to make a legitimate appeal to both individual and national pride.

With respect to the first point, a few remarks may be made. The ability to absorb learning from books and teachers is not identical with the power to produce original work. "Quick to learn" does not warrant the assumption of a powerful intellect. Precocity sometimes distinguishes remarkable genius; but it is not infrequently premature ripeness of a mind of an inferior order. Trite as these observations evidently are, they find some justification in the prevalence of opinions that ignore them. The Japanese student of science must recognize the fact that he will win no honors in the race he proposes to enter, through the exhibition of a sponge-like capacity for absorbing. His rank as a scientific

man will depend entirely on the amount and the character of his original productions.

To make a wise selection among the subjects to be investigated, to carry forward the investigation unaided to a successful conclusion, to arrange the facts in a logical manner, to interpret them with sagacity, to distinguish clearly between verified conclusions and figments of the imagination, are among the important evidences of scientific ability. The world is now waiting for such evidences; and if Japan fails to give them, she will inevitably hear, and most assuredly deserve, the verdict of scientific imbecility.

Before attempting to present the claims of the zoölogical department upon the educational authorities for a larger share of attention than it has yet received, it may be profitable to consider briefly, what sort of a beginning this department has already made, and what are some of its immediate needs. This done, the assertions of the so-called "practical man," who denies the usefulness of biological studies, and thinks they may as well be abolished altogether, will claim attention.

With respect to what has been accomplished in the zoölogical department during the four years (1877-1881) just ended, it is obvious that we have to distinguish between the work of foreign instructors and that of Japanese students.

It meets the demands of simple justice and at the same time the purpose of this article, to draw the line of distinction as sharply as possible. It is highly creditable to the Japanese government to have encouraged scientific researches to the extent of enabling the University to publish a series of scientific memoirs; but the fact must not be ignored, that not one of these papers has appeared under the name of a Japanese. Japanese students and professors have aided more or less in these

researches; but the results of their labors have been incorporated—and justly so in some cases—with those of the foreign profesor under whose direction they were executed. As we are here considering the position of the Japanese student, we shall be doing no injustice to any one, if we keep him in the foreground. It is all the more easy to do so, since the labors of Professor Morse in Japan are so well known that any allusion to them, beyond what is required to render clear the present situation, would be superfluous.

To Professor Morse belongs the honor of establishing the present course of zoölogical instruction in this University; and it is largely to his energy and unbounded enthusiasm that the students of zoölogy are to ascribe whatever opportunities they have since enjoyed.

The discovery of the Omori shell mounds, although not in the direct line of zoölogy, served the important purpose of awakening a general interest, which was sustained by further discoveries, as well as by courses of entertaining and instructive lectures to the students and to popular audiences. The interest thus aroused was fanned into a flame of popular favor by the varied and untiring activity which Professor Morse displayed, both in scientific research, and in those things which concerned the general welfare and progress of Japan, as also by the genial cordiality and unstinted hospitality which he extended to the Japanese.

Avoiding eulogy, of which there is no need, and criticism, of which there has already been enough to satisfy the cravings of most malicious envy, we have here attempted, by the statement of simple undeniable facts, to account for the influence Professor Morse acquired in Japan. The public confidence and esteem which he enjoyed, formed at once the most essential condition of, and the most powerful stimulus to, the

liberality of the government in making appropriations for those extensive dredging operations and inland excursions which resulted in the creation of an archæological museum, in forming the nucleus of a zoölogical museum, and in giving the University the first, and one of the most important, of its scientific memoirs. The zoölogical students accompanied Professor Morse in his excursions, and were thus brought face to face with the objects which it will be their business to study in the future, and made acquainted with the ways and means of collecting and preserving marine and other animals. As to laboratory instruction and lectures, this may be said, that much more was accomplished than could have been reasonably expected, considering the time and energy required in other directions. For students who had received no proper preparatory training, elementary instruction was first of all required. No attempt was made, so far as I know, or could have been safely made, to introduce the students into special lines of zoölogical research. At the close of his two-years contract, Professor Morse declined to renew, and thus the task of taking the students through the two years remaining to them fell to the lot of his successor.

With reference to the plan to be pursued, it is evident that any course which promised to subserve best the interests of the students and those of zoölogical science at the same time, deserved to be preferred to any which failed to combine these two sets of interests. Two alternative plans presented themselves, each appearing to satisfy this two-fold claim with about equal advantages. One plan was to start one or more investigations in which the students could participate as assistants, with the understanding that the results they reached should, after revision by the instructor, be incorporated with his own and published under his name.

The other was to set each student at work on some special line of study, with the understanding that, if he produced anything worthy of publication, it should appear in his own name. With reference to the point of paramount importance to the Japanese student of zoölogy—practical knowledge of the methods of investigation—both plans offered about equal advantages; but in regard to the distribution of honors—assuming that there would be such—there was a difference of no small importance. The first plan would relieve the student of nearly all responsibility, and at the same time of all credit, save perhaps a few scraps of flattery, such as are ordinarily sprinkled in under the head of acknowledgements. The second plan would give a much larger share of both the responsibility and the credit of the work to the student. If this plan had the merit of offering the greater encouragement, it could also be said to involve considerable uncertainty. The first plan was the safer, and, as it would have met all the more important demands of the situation, would have undoubtedly been commended as the wiser course by many, if not the majority, of those most competent to decide such a matter. Had it been adopted and successfully carried out, there is now every reason to believe that it would have given complete satisfaction to the University authorities, and passed without a criticism from any quarter. But the other course was preferred for the following reasons:—

1ST.—It aimed to do the utmost possible for the honor of both the University and the students.

2ND.—It offered the best opportunity for testing the ability of the student in the direction of independent investigation.

3RD.—It afforded the best means of correcting the dangerous element of self-sufficiency, and at the same

time of developing that rational self-reliance which independent action alone can give.

4TH.—It appealed with greatest effect to the ambition, and would thus supply a powerful stimulus to exertion.

5TH.—Its success would inspire confidence, and act as one of the strongest incentives to future efforts.

6TH.—It was the most direct way to reach what we have repeatedly and emphatically declared to be an object of the utmost importance,—namely, *the production of scientific work by the Japanese.*

But far greater difficulties attended the adoption of this course than have yet been mentioned; and if any apology is needed for calling attention to them, it will be found in the fact that no just estimate of what has been accomplished can be formed by any one who ignores them; and further, in the fact that those who should be most deeply interested in whatever success has been achieved, have failed to give any evidence, by word or act, that they appreciate either the character of the aim or the difficulties in the way of its attainment.

It was necessary to select subjects for investigation of such a character that special and general instruction could be combined. It would have been a comparatively easy task to set each student at work collecting and describing new species of animals; and such work would have been doubtless pleasant, and not unprofitable considering that so much remains to be done here in Systematic Zoölogy. But had this been done, one of the most important sides of the student's education would have been neglected, and he would have been left in a half-fledged condition, impotent to take part in the decision of those questions that are now engrossing so large a share of the zoölogist's attention. A knowledge of the methods of microscopical research has now

become an imperative necessity to the zoölogist; and any failure to have provided for this would have justified a verdict of incompetency against the person responsible for it. To impart this knowledge, and to aid in carrying on special researches at the same time, have been the aim of one who has had both the honor and the misfortune to follow Professor Morse.

Only two years remained for carrying out the plan determined upon, and eight months of this precious time had passed before the microscopes and microtomes, ordered from Germany, could reach us. It was impossible to accomplish much in the way of preliminary training without proper instruments, and so the eight months were devoted mainly to general anatomical studies. Of the sixteen months remaining, only twelve could be counted on for work—less than half the time necessary to insure success. When we consider that in a German university it requires from one to three years, even after the student has become tolerably familiar with the use of the microscope and microtome, to produce an acceptable thesis, it becomes evident that our time had been reduced to the minimum. This modicum of time was rendered almost hopelessly inadequate by certain unfavorable circumstances, some of which must now be mentioned. The students were remarkably deficient in that previous information on which one can count in a student who has gained admittance to a first-class Western university. This cannot be put down to the discredit of their former teachers; nor is it more than partially explained by the fact that the Japanese student can forget with as great facility as he learns. The simple truth is this, there is at present no preparatory course of instruction which can meet the requirements of candidates for the special course in zoölogical study. Whatever be the subject of investigation, the

student finds himself promptly confronted with a more or less voluminous mass of literature relating directly and indirectly to his work, and requiring for its mastery a knowledge of three or four languages. He is tolerably familiar with only one of these languages—the English—and is thus unable to avail himself of at least two-thirds of the helps to success. To suppose that it falls within the province of the instructor to supply such a deficiency, would be a gross misapprehension of his duties. His part in this matter is done, when he has told the student where to find the literature, and pointed out its general character. But there was but one way out of the difficulty, and this was for the instructor to do, so far as possible with the books at his command, what previous instruction and dictionaries could not do. One of the most discouraging features of the case will hardly bear more than a passing allusion. In view of such disadvantages as lack of time, insufficiency of previous instruction, inadequate libraries, &c., it would seem that nothing, beyond a decent appreciation of the object aimed at, would have been required to enlist the sympathy and co-operation of the officer who has, until quite recently, figured as the second head of the Science Department. A rehearsal of the facts would certainly be offensive, and so we leave the reader to infer what we here refrain from stating; reminding him only that we have received all the sympathy that could be squeezed into affable smiles, all the co-operation that bland and meaningless words could give, and all the attention, encouragement, and inspiration that could be wafted to us from official coat-tails that bustled through the laboratory once or twice a year. If, under the adverse circumstances above noted, and others which we decline to specify, out of consideration

for the feelings of the person in whose policy of obstruction they originated, and because the Science Department has now been permanently relieved of his services, our plan has been brought to a successful conclusion, let whatever merit there is in the achievement be credited mainly to the patience and persevering industry of the students. For whatever share the writer's efforts may have had in securing a successful issue, he feels abundantly repaid by the gratitude of his pupils, and by the fact that the publication of their papers will be the means of obtaining a verdict on his work as a teacher from competent judges, He may also confess to a feeling of moderate gratification arising from the fact that the first scientific memoirs produced by Japanese will bear the names of his pupils. As these memoirs will soon be published, no special notice of their contents is here required. A summary of the more important results would be of little interest to any one except the specialist; and any discussion of their theoretical bearings, which could interest the general reader, would come within the scope of a review of the published papers more properly than here. It is enough for the purposes of this article to say, that a thoroughly successful beginning has been made—a beginning that is all the more creditable on account of the obstacles that had to be overcome. But the fact is not to be overlooked that it is only a beginning, and that the test of what the student can do when left to his own resources is yet to be made.

Among the most urgent needs of the Zoölogical Department is a more complete library. The student just beginning the study of Zoölogy requires, in addition to a competent teacher, a few standard text-books and books of reference. But when, after acquiring a

certain amount of general information about the animal kingdom, he undertakes an investigation, his needs suddenly expand, and become co-extensive with the complete bibliography of his own subject and all cognate subjects. Nothing but the books themselves can then satisfy the demands of the case. No teacher, however well versed in zoölogical literature, can play the part of a library. Allowing—what has long ago ceased to be even a remote possibility—that the instructor's brain could perform that encyclopedic function of giving the title, date, and a summary of the contents, of every zoölogical work that has ever appeared, even such a miraculous brain would not remove the necessity of a library. Indeed, it could do nothing beyond increasing the usefulness of a library. It would be able to direct the student to original sources of information; but it could not reproduce the exact words of authors, with explanatory diagrams, illustrative engravings, &c. Yet these are the very things the investigator must have, in order to obtain that complete and precise knowledge of what has been done, which alone can insure his own success. On almost any zoological subject that could now be proposed for special study, more or less has already been written; and in order to test the accuracy of the results recorded, or to make them the foundation of further discoveries, the student must of course be familiar with them. Without such knowledge he can make no intelligent choice among the problems to be solved, nor any wise selection of the ways and means of solution. In all matters it is wise to profit by the experience of others; in Zoölogy, it is a necessity. The painful experience of the zoölogical student has in many instances borne testimony to the truth of these remarks. While it may be said to the credit of the University, that a liberal share of the money to be expended in books

during the past two years was devoted to the purchase of zoölogical works, we shall not soon forget that, with the inadequacy of the expenditure was needlessly coupled what we may mildly call official prevarication—a practice which, if not avowedly sanctioned, is at least tolerated in this University. This fact, like several others of the same obnoxious charactr, will cleave to the memory all the more tenaciously, as it was the means of our not obtaining certain much needed books, which could, and would have been procured at our own private expense, had we been correctly informed with regard to the non-fulfilment of our orders. Since the library can not be made complete at once, the question arises, what should be done first? Beyond what has been said, one suggestion may be offered, namely, that the library be first of all supplied with all the leading zoölogical journals; and that some arrangement be made through which the new numbers may be sent *directly* to the University as soon as published. The present mode of buying involves the loss of about half the money in "squeezes," and a most intolerable waste of time.

The wants of the laboratory call for a few remarks. Of all that remains to be done, there is perhaps nothing so important as good aquaria. Such aquaria are not represented by small glass vessels, or wooden tubs, filled with well-water. There must be glass tanks, large enough to keep in a healthy condition such fresh-water animals as are to be made objects of study. One of the students has failed to obtain from the common Triton the requisite number of eggs for completing his observations on the early stages, simply because he had no means of keeping them under normal conditions. For the same reason another student has failed to get any eggs at all from the Giant Salamander (*Cryptobranchus Japonicus*), and has even lost many specimens which

he collected with great trouble and expense. This is one of the most interesting animals found in Japan; and it is to be feared that the few still left will soon be exterminated by the fishermen, who drag them from their cool retreats in the mountain streams and kill them for food and medicine. The University would be doing an eminent service to science, should it provide some one with the means of making a through study of the life and development of this creature, which is perhaps the nearest surviving relative of the celebrated fossil Salamander (*Andrias Scheuchzeri*) which lived many thousand years ago in Europe. A comparison of the habits of this animal with those of Triton and the Axolotl of Mexico (*Amblystoma Mexicanum*) would open the way for some interesting experiments. It would be well to repeat the recent experiments of Professor Gasco with Axolotl ("Les Amours des Axolotls," in "Zoologischer Anzeiger," Vol. IV, Nos. 85 and 86, 1881). Almost nothing is known of the early stages of this Salamander; and nothing whatever about its breeding habits, and the growth and development of its eggs. If the authorities of this University are anxious to see zoölogical science flourishing in Japan, let them provide the means for studying such important subjects. So far as the expense of making ponds and aquaria is concerned, would it not be more economical to provide at once these necessary means of investigation, than to go on wasting time and money indefinitely collecting animals to no effect?

The Zoölogical Department needs and deserves the generous support of the Government, and there are important reasons for giving this at once. Thus far all the zoölogical work that has been done in Japan, has been done by foreigners. Until quite recently the learned men of this country have looked down from those

pinnacles of Oriental wisdom on which they have perched for centuries, with the utmost unconcern, while the despised foreigner has been quietly studying the fauna and flora of these islands. The resolution has at last been taken to make amends, so far as possible, for past inactivity. But if the effort is worth making, should it not be made with such effect as to command respect? Making all due allowance for the present financial embarrassment, it is still an easy matter to supply aquaria and such books as are indispensable to the success of whatever investigations are undertaken. This is the minimum of what the student has a right to demand from those who have persuaded him to enter upon a competitive course, from which he cannot now retire without disgrace to himself and dishonor to them. Any failure on his part, not attributable to incapacity, must be charged to a culpable lack of energy and zeal on the part of his supporters. What stronger incentive to industry does the student require? And what greater spur could be applied to the liberality of his patrons, who profess a desire to see the present moping stupor, generated by centuries of lethargic slumber, replaced by that healthful vigor and stirring activity which characterize all progressive nations? There is every encouragement that rare opportunity can offer. The student of zoölogy has advantages superior to those enjoyed by students in any other branch of science, except Botany. He has a field that may still be said to be new—a field which previous cultivation has not impoverished, but rather prepared for richer harvests. The labor thus far has been mainly of a systematic kind, such as collecting, describing, naming, &c. This is only the drudgery of Zoölogy, and enough of this sort still remains to satisfy the wants of those who may be incapable of rendering any higher service to science.

But beyond and above the collector's range lies the real vineyard of Zoölogy. Here let the student enter, and behold what bountiful provisions nature has made for those who have the courage and ability to do so.

Let us consider now how liberally nature has provided for the Japanese biologist. She has cut off a strip of land from the continent of Asia by means of seas and straits, and divided it into a chain of many islands, stretching through fully 25° of latitude, from Kamtchatka on the north to the southernmost limit of the Liu Kiu Islands. These islands are so many great zoölogical gardens, so disposed that they extend nearly through the best two thirds of the temperate zone. But these 3,000 or more island gardens included in the Mikado's Empire, are supplemented on the north by the Aleutian Isles, and southward they lead through the Philippine Islands into the great Australasian group. For immeasurable periods of time, the Japan Islands have been isolated from one another and from the mainland by the encircling ocean, which forms around each a vast marine aquarium. In the formation of these islands, portions of the continental fauna became inclosed, and such animals as could not fly or swim from shore to shore—passing over the possibility of transportation through the agency of winds, currents, and migrating animals—were henceforth confined within the limits of their respective islands. Could human wisdom have devised a more efficient and comprehensive plan for testing some of the great questions which have been so much discussed since 1859? Nature has certainly been experimenting here on a grand scale, and for a length of time that defies all calculation. The results of her experiments are to be learned by a comparison of the faunas of these islands with one another and with that of the continent from which they were

severed. The long isolation under more or less altered conditions of life, has afforded an opportunity for adding increment to increment of change, until the animals exhibiting the cumulative results differ, as a rule, to a more or less conspicuous degree from their nearest living allies in Europe, Asia, and America. For numerous instances we may refer the reader to Von Siebold's "Fauna Japonica," to the University memoirs of Professor Morse and Professor Brauns, and to recent papers by Mr. Lewis and others. One interesting case, which has received special attention from the writer, is found in a small freshwater fish, very common about Tokio. There is in Europe a well-known little fish, called *Rhodeus amarus*, which has the very curious habit of depositing its eggs in the gills of a mussel *(Anodonta)*, where they remain until they hatch and the embyos have attained a considerable size. For the deposit of the eggs, the fish is provided with a tube one to two inches long, by means of which the eggs are delivered to the care of the mollusk. The coloring of the male fish during the breeding season is remarkably brilliant. Now at least three varieties of this fish are to be found in the brooks and ponds of Tokio, possessing all the above-named peculiarities and habits, but with differences so pronounced that they may be easily distinguished from one another and from the European species.

Among the marine fishes may be mentioned the remarkable White-fish found along the coast and in the rivers of Japan, called here "shira-uwo" *(Salanx microdon)*. This interesting fish, transparent as a Jelly-fish, is unquestionably a congener of the "white bait" of Macao *(S. Chinensis)*.

Then there is a small crayfish *(Astacus Japonicus Sieb.)* found in Hokkaido (Yezo), whose affinities with the river crayfish of Europe *(Astacus fluviatilis)* are

shown not only by its structure and habits, but also by the parasites it bears. The European species bears two small leeches, known under the generic name of Branchiobdella. The Japanese crayfish has three distinct species of these parasites, two of which are more or less closely related with those found in Europe, while the third is altogether a new species.

Besides the important lessons to be learned by comparing the faunas of these islands with those of Europe and Asia, there is perhaps equally interesting information to be gained by studying the relations which exist between the faunas of the islands themselves. Very little has thus far been done in this direction.

Again there is an opportunity within the limits of the main island to trace the effects of climatic and other local differences. As an illustration of what may be done in this field, we may refer to the very interesting observations of Mr. Lewis, who has succeeded in producing evidence of a very striking kind, that at least six species of apterous beetles now living in the two main islands of Japan, are descendants of a common form; and that this form itself *(Damaster blaptoides)* can probably claim a common parentage with a genus *(Carabus)* found throughout the Northern hemisphere. The case is one of such general interest and importance that we can well afford space for Mr. Lewis's own words, which he was kind enough to write out for me. "In Nagasaki there is a long sub-tropical summer, with little change in the shade from day to night; and the lalitude gives little or no twilight. Here we find *Damaster blaptoides*, measuring about 2½ inches, black in color, and nocturnal in habit. It lives under the shade of large evergreen trees, and we can imagine that the sun rarely shines upon it. Crossing the Bay of Simabara, adjacent to

Nagasaki, we find a sandy soil, with small conifers, and a volcano often topped with snow in winter. The trees are small, owing to the soil, and are easily penetrated by the wind in winter and the sun in summer. The form we find here *(D. Lewisi Rye)* is that of a half-starved specimen of the Nagasaki species, measuring 1 inch 8 lines, with short legs, and a *bluish* tint, which is general in all the examples. In Hiogo, the Simabara form of Damaster is found. In the district of Yokohama is found *Damaster pandurus* Bates — a slightly modified form of D. Lewisi. The thorax is shorter, and the individuals more constantly blue. In the higher places around Nikko, to which place this species extends, I have procured specimens with metallic-blue thorax and elytra. These bright specimens came from altitudes where on the 15th of June (1880) snow remained in shady places, and where birch-trees are denuded of their leaves by the middle of September. At Akita and northward to Awomori, there is another species (D. viridipennis Lewis). This has green elytra, and a bright crimson metallic thorax; and is one of the most highly colored Coleoptera in Japan. The climate of the district in which this species is found is many degrees colder than that of Nikko, especially on the west coast where the full effect of the northwest wind—the cold wind of Japan—is felt.

In Yezo we find *D. regipennis*, which has the bright thorax of the last, with deep purple-colored elytra. In the south it has about the same size as D. viridipennis; but a specimen obtained from Cape Soya, the northern extremity of Yezo, measured only one inch in length. Another distinct species is found in Sardo, an island off the west coast, which is very remarkable for the crassitude of its head and thorax, and which I have therefore named *D. capito*.

We have seen that the Nagasaki species is black and nocturnal in habit, and the Hiogo species is probably the same. But I think the Yokohama species, in which color first appears, is diurnal, or at least crepuscular in habit; for we here begin to enter the region of twilight. In the mountains of Nikko, where the brighter examples of this species are found, they can enjoy but a short summer; since the deciduous trees here bud in June and are denuded by the middle of October. I think it natural for a species under these circumstances to become gradually diurnal, especially if it be the descendant of a southern type and consequently of a warmth-loving nature. At Akita and in Yezo, both species are bright colored; and I have secured specimens roaming about during broad daylight and feeding on the sap of trees at noonday."

Mr. Lewis regards the black southern species (D. blaptoides), which is noctural in habit, as the parent form, and so finds no difficulty in explaining the smaller size of the more northern species. The gradual transition from nocturnal to diunal habits is also easily accounted for; and to this change in habit, the northern species owe their brilliancy of color.

An interesting case of variation in the Japanese Triton has come to our notice. All the specimens recently obtained from Kobé differed uniformly from the Tokio type, in being longer, much more slender, paler in color, and in having the tip of the tail irregularly prolonged. If they are not to be called two different species, the question arises, which is the species and which the variety? Numerous instances of a similar character might be cited; but these suffice to illustrate the point in question, and to show what interesting problems concerning the genesis of species are here offered to the inquiring student.

Among the conditions favorable to the transition from aquatic to terrestrial life is a saturated atmosphere. This condition is found in Japan; and it is here that we find some very interesting cases of true aquatic animals living on land. Every one knows that the Medicinal Leech is a fresh-water animal. This leech has the habit of crawling partly or wholly out of water, when the air is so saturated with moisture that it can do so without exposing its skin to desiccation. The question naturally arises, could such a creature ever become habituated to living on land? When we remember that the skin of the Leech performs the function of lungs, and that, provided it is kept wet, it is capable of drawing its supply of oxygen from moist air, there is no difficulty in understanding how such a change might be induced. Experiment has already shown that some water-breathing animals can without difficulty become air-breathers. The Mexican Axolotl is a well-known instance; and the Lymnaeidae which belong to the deep-water fauna of the Lake of Geneva form another. Nature herself supplies us with numerous examples in which such a change is a normal occurrence in the animal's cycle of life. No one has undertaken to test the matter in the case of the Leech; but there is every reason to believe that Nature has made this experiment, and that the Land-leech found on the mountains of this island and in some other parts of the world, is a living demonstration of her success. In this country the Land-leech is found near the tops of mountains, in dense thickets, where the ground is carpeted with moss and other low plants. During the dryest months of summer, these localities are kept moist by mists and showers. The structure of the Leech has been modified to some extent in accommodation to its present mode of life; but this modification is in every particular one

of adaptation. Not an organ has been lost or acquired. Certain organs have been compelled to do more work in the Land-leech than they do in the common Leech; and the natural result has been multiplication and enlargement. The skin-glands have become larger and more numerous, and the urinary vesicles have expanded into bladder-like reservoirs. The liquid secretions of these organs supply any deficiency of water in the air, enabling the leech to keep its dermal respiratory organ constantly moist.

The land Planarian forms also an interesting example of the kind here considered. This worm, which creeps about in damp weather, somewhat like a slug, is abundant in this island, and in many of the islands to the south. It has a wider distribution than the Land-leech, being found in nearly all temperate and tropical zones, not only on islands, but also on the continents, where the moisture of island atmosphere prevails.

There is another very remarkable case, allied in some respects to those just mentioned. What could seem more out of place than a fish on land! It would seem that fishes are especially adapted to live exclusively in water. In providing the fish with fins and with a respiratory organ in the form of gills, nature seems to have decreed that one class of animals should have a place and keep it. But all her devices to keep certain members of the finny tribe within the prescribed medium have failed. Among those remarkable fishes which have succeeded in overcoming every obstacle to living out of water, at least one very interesting species occurs on the coasts of Japan. This is the jumping-fish (*periophthalmus modestus Sieb.*), or the "Tobihaze" as the Japanese call it. This fish is more truly amphibious than the frog, for it is able to change the mode of its respiration

at pleasure, breathing water and air alternately. It is accustomed to spend a great part of the time out of water, and actually appears to prefer the air to water. If one attempts to capture it, it rarely, if ever, plunges into the water, but skips along the surface. It can climb up the steep sides of rocks or plants, and jumps along the shore in quest of insects and other small animals, with the agility of a frog. When out of water, it puffs up the cheeks with air, which is held for a short time and then renewed.

There is another important feature of the situation here, which certainly deserves consideration; namely, the easy access to the sea. Whoever knows anything of the history of "Seaside Schools," knows how highly naturalists esteem the advantages offered by such institutions. Since the idea of maintaining zoölogical stations at the seaside was first acted upon by Carl Vogt in Europe, and by Prof. L. Agassiz in America, many stations have been temporarily or permanently established. The more important of these in Europe are the station at Naples, under the directorship of its founder, Dr. Anton Dohrn; and those maintained by the Universities of Vienna, Lille, the Sarbonne, of Paris, Aberdeen, and New South Wales. In America the best marine laboratories are the private laboratory of Mr. Alexander Agassiz, at Newport, designed to carry forward in a somewhat different direction the enterprise started by Prof. L. Agassiz at Penikese; and the Chesapeake zoölogical Laboratory, established by the Johns Hopkins University, and placed under the directorship of Dr. W. K. Brooks, who originated the plan. Naturalists have been quick to avail themselves of the opportunities offered by such laboratories; and the work produced in them ought to be sufficient evidence to every right-minded person of the great value of such an appendage

to an university. Prof. Morse was the first to call the attention of the Japanese government to this matter; but his advice was not acted upon. It is to be hoped, however, that at no distant date the importance of the suggestion will be seen, and that a marine laboratory will then form one of the most valuable and attractive adjuncts of the University of Tokio. It is no exaggeration to say that on the coast of Japan are some of the most favorable localities in the world for such a laboratory. This fact, together with the close proximity of the University to the sea-shore, presents a rare opportunity, which it would be criminal long to neglect. We can imagine that the laconic answer to all this might be "No Money." But such a response would exceed the truth, and fall far short of common sense. Will any Japanese admit that Dai Nippon, with its 3,000 islands and 34,000,000 inhabitants is not able to support *one* first-class University? Until some one is prepared to make such a confession, the above objection is not worth considering, and will hardly bear mentioning even as an apology for not embracing at once an opportunity so full of promise.

The real difficulty is not that there is no money, but that there is so little market in this country for anything that is neither tintinnabulous nor convertible into kin-satsu. Any science that offers small opportunities for pilfering "squeezers," makes no promise to improve the rice-crop or the flavor of the saké, serves none of the wants of sensual pleasure, jingles no bells, and refuses to make use of the sop of flattery, may be suffered to exist for the sake of appearances, but is certain to be stigmatized as unprofitable. The "practical man" of Japan belongs to that cosmopolitan class to whose distribution there are no limits either in space or time. A diagnosis

of the Japanese species reveals its identity with that so well known in other parts of the world. Gentlemen of this stripe have occasionally lost their way so far as to stray into the zoölogical laboratory. They have perchance found some student dissecting a monkey, or injecting the blood-vessels of a frog; others at work with microscopes, and accessories in the form of acids, staining-fluids, &c. To their "practical" minds all this was "sheer play." Well, the students have appeared to enjoy this sort of play none the less because others of a more practical turn of mind could not see the fun. This "unprofitable play" has proved so attractive that not a few entire nights' sleep have been sacrificed in its behalf. The practical man was astonished to see what enthusiasm there could be in such amusement, and still more so to find that it had ended in the production of papers of considerable scientific merit. Through these unexpected results, the practical twist of his mind has been so far straightened out, that he is now inclined to see nothing but "pure science" in what was first declared "play." There might be nothing to object to in this, if no distinction between "pure" and "applied" science were insisted upon. As the practical man appears to hold the reins, it may be worth while to meet him on his own ground, expose the obliquity of his vision, and demonstrate that he is the most unpractical of all men. In order to do this, it will only be necessary to show that Zoölogy, like every branch of natural knowledge, has its practical side, as well as its experimental and theoretical sides. But it is a great mistake to suppose that the practical side can exist independently of the other sides. It is the same with the biological as with the physical sciences; observations are made and critically compared, general laws established, and then deductions made and applied. The order of these three

steps cannot be reversed; nor can the third step be successfully taken, if the first two are omitted. Principles must be ascertained before they can be applied. The ability to make them of some practical utility, presupposes a knowledge of them; and this knowledge can be acquired only by purely scientific training. If then applied science draws its resources wholly, or chiefly, from so-called "pure science," it follows that the former can flourish only where the latter is cultivated. From this stand-point the distinction between pure and applied science is evidently one which can not be maintained. We claim that all science is practical in the truest sense of the word, since it is at once the cause and the consequence of human progress. It may be admitted that the whole body of science can not be put to direct and immediate use, and herein lies the sole ground of the distinction. But is there a fixed quantity of scientific knowledge that can be so applied? Does not the whole history of what is called applied science show that it is simply that portion of pure science which we have learned to utilise? Does it not further show that the quantity has no fixed limit anywhere this side of the whole body of science? Who does not know that what may be called pure science to-day, may to-morrow become the most valuable part of applied science? Pure science may then be regarded as the applied science of the future, and thus the distinction is reduced to one of tense. If progress requires the continued extension of the field of applied science, it also requires that the sphere of pure science shall be ever expanding. The real error of the practical man is the assumption that it does not pay to cultivate science which has no immediate known use.

Before passing to the more obviously practical side of Zoölogy, the question of culture may be very

briefly noticed. No one whose opinion is worthy of notice would deny that culture has, in addition to its intrinsic worth, a decidedly practical value in all the more important business relations of life. Success may be achieved without it; but there can be no doubt that, other things equal, success will be incomparably greater with culture than without it.

It can no longer be claimed that culture consists exclusively in a knowledge of ancient and modern literature, the Hebrew and Christian Scriptures, or any one of the sciences. The scientist cannot attain full culture, unless he adds to his special knowledge a general knowledge of other sciences, and an acquaintance with the best that the literary world affords. Nor is complete culture to be obtained by an exclusively literary training. The time when this was possible has passed; a general knowledge of what science has done and is now doing has become a necessary part of a liberal education. Formerly the colleges and universities of the West were monopolized by literary studies, to the almost complete exclusion of science. Even now the contest has not ended which is destined to give science that place in education to which it is entitled. But the victory is so far won that we can now predict with certainty, that the culture of the future will have not only its æsthetic and literary sides, but also its scientific side.

"Perfect culture," says one of the most eminent biologists, and one apparently familiar with "the best hat has been thought and said in the literary world, "should supply a complete theory of life, based upon a clear knowledge alike of its possibilities and of its limitations." If we accept Prof. Huxley's definition, which supplements "the critcism of life contained in literature" with that contained in science, it

is evident that Zoölogy must supply one of the important parts of culture.

"But," interposes the practical man, "knowledge, culture, refinement—that may all be well for the few who care for it. What we need is something that will meet the wants of all—something that will make us successful business men, and fill our pockets with gold; teach us how to make life more comfortable, prosperous, and happy; secure us against every disease that flesh is heir to; protect us against noxious plants and animals; instruct us how to make Nature's forces do our work; fill us with love of the truth, and hatred of the false;—in short, anything and everything that can increase the sum of human happiness."

So it always turns out; when the practical man's wants are made known, they coincide, in the main, with those of other people, not excluding those who find their highest happiness in the pursuit of knowledge. The great mistake lies in thinking that money is the chief means of satisfying all these wants, and that education should therefore be directed to fitting men for money-making. We would not under-estimate the value of such an education; but would respectfully remind those who advocate it to the exclusion of other branches of education, that they betray a most lamentable ignorance of what the cultivation of that worthless thing, pure science, has done for the world within the last three hundred years. What has enabled us to harness Nature's forces to our cars and steamers? Could money construct a steam-engine, or an ocean cable, or even furnish the materials of which they are made? If money be so omnipotent, why did the world wait so long to enjoy the benefits of these and a thousand other discoveries of modern times? The practical man is too prone to forget that the human

brain is the great engine of progress, and that the whole fabric of modern civilization rests on science. What accounts for the superiority of Western over Eastern civilization? What has so long maintained the intellectual stagnation of this country, and made it a veritable beggar at the door of more progressive civilization? Why is Japan cursed with revolting superstitions, destitute of enterprise, and under the sway of caste? What has made the price of human labor here so cheap that the labor of the beast can not compete with it? Why this almost total absence of those great ideas of industrial development, commercial enterprise, and social improvement, which characterize Europe and America? To all these inquiries one answer may be given—*The absence of the scientific spirit.*

What has given Germany the domination of the intellectual world; and what has made her universities the most scholarly and most productive institutions we have yet seen? The cultivation of pure science. Why have not those wealthy English universities of Oxford and Cambridge become seats of learning of equal influence with those of Leipzig and Berlin? Simply because they have refused to accord to science the place it is entitled to hold in the curriculum of a university. Science in England flourishes outside the universities, and in spite of them. This explains how a learned rector of an English college could declare that these celebrated institutions had degenerated to mere "boarding schools"; how the commissioners could complain "that so few books of profound research emanate from the University of Oxford"; and how a distinguished Englishman, a well known authority in educational matters, could say that, "as for works of profound research on any subject, and, above all, in that classical lore for which the universities profess to sacri-

fice almost everything else, why, a third-rate, poverty-stricken German University turns out more produce of that kind in one year, than our vast and wealthy foundations elaborate in ten." The intellectual eminence of England is universally acknowledged; and if her universities are inferior to those of Germany, it can not be attributed to dearth of Classical or Biblical piety, or to sterility of intellect, but to the fact that these have not extended a generous welcome to science.

Let those who think that pure science is a matter of secondary importance to a university, turn to the German universities, and in their prosperity and powerful influence witness the demonstration of the absurdity of the idea. No sound-minded person who becomes acquainted with these institutions, can fail to see the practical wisdom of fostering science. Nothing can exceed the catholicity of aim which they display, for they undertake to represent universal knowledge; and they do it in a manner worthy of the name they bear. Here every form of intellectual activity is encouraged and allowed free scope. The professor enjoys perfect freedom in respect to the matter, form, time, and amount of instruction, and is thus in a position to devote a large share of his time and energy to special research. The independence of the student is scarcely less than that of the professor; for he is free to study what he pleases, as much as he pleases, when he pleases, and as long as he pleases. Having prepared himself in the requisite number of branches and presented an original production acceptable to the Faculty, he may call for an examination at any time that suits his convenience, and, if he passes the cross-fire of his examiners, receive his degree. Such a system is obviously perfectly adapted to the production of the largest amount of original work. It is thus that the German

Universities succeed in producing in many, if not the majority, of the sciences, more work than the universities of all the rest of the world combined. They are Germany's great centers of power, influence, and progress, radiating the light of knowledge to every part of the empire, and to every other portion of the globe where science has any votaries.

Now what would Germany be without these universities? Take away these foundations of her intellectual pre-eminence, and away would go her political supremacy. The proud position which she now holds as arbitress of Europe would be at once wrested from her; and the other great powers would swallow her up, or reduce her to a condition of dependence as humiliating as that of Turkey in Europe.

Japan is to-day at the mercy of foreign powers for no other reason than that she has so long preferred ignorance to knowledge. She is held as in a vise, unable to obtain a revision of the treaties with foreign powers satisfactory to herself,—powerless either to remove the restriction imposed on her authority by consular jurisdiction, or to assert the right she claims to regulate and control her tariff. We are here dealing with facts and with the means of amelioration, and are therefore not called upon to enter into any partisan discussion. The question which every patriotic Japanese has to answer is how can we rise above the tutelage of foreign powers? It requires no gift of prophecy to foresee that foreign domination will continue so long as there is any good reason for it. If Japanese wish it to cease, then let them reflect that every dollar spent in the cause of education will hasten the consummation so earnestly desired, just as certainly as every cut in the appropriations will postpone it.

How short sighted and suicidal then the policy that would feed an infant university on stones instead of bread,—that would seek to save the nation by destroying the only means of salvation,—that would seek to replenish the nation's coffers by starving the fountain-head of all prosperity. Such a policy was that of the silly old woman who killed the bird that laid golden eggs.

"But we are poor and cannot afford to throw away money for the promotion of science." That is not the view taken by the Germans, who put such vast sums of money every year into libraries, museums, laboratories, and lecture-halls; who support a whole army of scientists, and provide them with all the aids to research that money can buy. The amount of money consumed in this way is certainly enormous; and, to one who could see nothing in a museum but a collection of curios, nothing in a library but a depository of unproductive knowledge, nothing in laboratories but playhouses, it might seem that such things were mere contrivances for wasting time and money. But one need not rise far above the plane of average intelligence to see their bearing on a nation's welfare, and to realize the fact that laboratories are brain-factories, which no country can afford to do without.

Having pointed out some of the important results that would follow the cultivation of science, we will now turn again to the special case of Zoölogy. There are some who look upon Zoölogy as one of the least useful sciences. This notion must arise from ignorance of its history, its scope, and its aims, Anything like a thorough discussion of these heads would require much more space than can here be given; but a few considerations will perhaps suffice to show that Zoölogy is an intensely practical branch of knowledge. That the

reader may have the opinion of one who can not be charged with the bias of a specialist, the following remark by President Eliot of Harvard University, made at the Semi-centennial of the Boston Society of Natural History, is introduced:—

"*The human race has more and greater benefits to expect from the successful cultivation of the sciences which deal with living things than from all the other sciences put together.*" Then, after a brief notice of what mechanics and physics have done within a hundred years, comes the following:—"The fact is, that mechanics, and physics deal only indirectly with those natural evils which are the main causes of human misery,—namely, climatic influences, not understood, and therefore, not to be guarded against, violent and unpredictable extremes of heat and cold, wetness and dryness, ravages of noxious plants and animals, diseases both of men and of useful animals, and untimely death. All these evils belong to the domain of natural history, and for ultimate deliverance from them we must look to the student of natural science."

In illustration of the truth of these remarks, a few special cases may be cited. First of all we would call attention to some of the important benefits conferred on humanity by the biologist's "toy," the miscroscope. A, whole world of living organisms, lying beyond the ken of the naked eye, has been discovered—a realm of life in which all ordinary distinctions between plants and animals entirely vanish. The fact that man has profited by this discovery in many unexpected ways, makes it a capable case for illustrating the short-sightedness of those who would discourage investigation, the results of which cannot be foreseen to be beneficial. We have already learned that some of these simplest and most minute forms of life are capable

of doing an incalculable amount of mischief,—destroying human lives by the hundreds and thousands, appearing in the form of destructive plagues among domestic animals, and spreading ruin over vast areas of valuable crops. It is some of these micro-organisms, commonly called *Bacteria*, that cause meat to putrefy, fruit to rot, milk to sour, and numerous other kinds of fermentation. Twenty years ago no one dreamed that all putrefaction was due to such agencies; and nothing was known of their relation to disease. Zoölogists and botanists have joined hands in this important field of study, and have accumulated a mass of information that has already been of the greatest service. The study of their cycle and mode of life, the conditions favorable and unfavorable to their multiplication, and their relation to disease, has already enabled us, in a measure, to protect ourselves against their dangerous attacks. The methods of surgery have been reformed by this new knowledge; operations are now successfully performed which would have proved fatal before the dangerous effects of *Bacteria* in wounds and the means of excluding them were known,

There is a large class of diseases, called "zymotic," supposed to be of the same essential nature as the putrefactive fermentation set up in wounds by these *bacteria*. A now celebrated bacterium, *Bacillus anthracis*, is known to be the cause of splenic fever, which has proved such a fatal epidemic among cattle, and which is capable of being communicated to other animals and to man. The hog plague, or typhoid fever of the pig (*Pneumo-enteritis contagiosa*, Klein), has been traced to another species of *Bacillus* by Dr. Klein, Septicæmia has been referred by Pasteur to a third species; and *Spirillum* one of the same group of fission-fungi, has been associated with recurrent fever. Another fungus (*Hemileia*

vastatrix) is now devastating the coffee plantations of Ceylon, India, and other coffee-growing countries of the East. In the West Indian Islands, and in South America, on the other hand, the coffee-leaf disease is produced not by a fungus, but by the larvæ of a small moth (*Cemiostoma coffeellum*). Many other diseases of animals and plants have been traced to the same or similar agencies; and, in many cases, remedies suggested by biologists have been successfully applied.

A very ingenious application of our knowledge of the diseases produced by fungi, appears to have been first suggested by a well known American entomologist, Dr. John L. Le Conte. His idea was to study the fungoid diseases of insects, with a view to cultivating them for use in destroying insect pests.

Quite recently a distinguished entomologist of Harvard University, Professor Hagen, has written a paper on the destruction of such noxious insects as *Phylloxera*, the potato beetle, cottonworm, greenhouse pests, &c., by sprinkling with dilute yeast. Professor Hagen has tested this method, and reports that it is effectual against the potato-bug and leaf-lice.

Professor Metschnikoff, an eminent Russian embryologist, has been studying the diseases of certain grain-beetles that have proved very destructive to crops in southern Russia, with a view to finding one that could be used in exterminating or checking the beetles. He has ascertained that one of these diseases, which sometimes appears as an epidemic among the grain-beetles and turnip-beetles, was caused by a parasitic fungus (*Isaria destructor*). To make use of this fungus as an insect-destroying agent, it was necessary to find some way of cultivating it that would yield quantities. He found that it could be cultivated in beer-mash, and that thus any required quantity of the

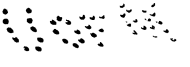
spores could be obtained, by means of which the disease (called by him "green muscardine") could be spread at pleasure.

A highly interesting discovery has been recently made by M. Pasteur, which proves an effectual remedy against the so-called fowl-cholera, which has made such destructive work in the poultry-yards of Paris. M. Pasteur has found a mode of cultivating the *bacterium*, known to be the cause of fowl-cholera, by which the *bacterium* is enfeebled, or so modified that it does not produce a fatal disease. Inoculation of a healthy fowl with this altered form produces only a mild form of the disease, but secures the fowl against the ordinary and fatal form. The fowl is thus vaccinated against cholera.

An equally important discovery of a similar nature has been made by Dr. Greenfield of England, who has found that cattle inoculated with virus from a guinea-pig that has died of splenic fever, are secured against the violent form of the disease.

In an address, delivered before the British Medical Association, to which I am indebted for the above facts in regard to vaccination, Prof. Lister remarks "No one can say but that ten years hence, some one may be able to record the discovery of the appropriate vaccine for measles, scarlet fever, and other acute specific diseases of the human subject."

An examination of the excreta of persons afflicted with cholera, has shown that this disease is accompanied with an abnormal abundance of a minute amoebal form of life (*Protomyxomyces coprinarius* Cunningham.) It has been assumed by some that this intestinal parasite is the cause of cholera, by others (Cunningham) that it is merely associated with the disease, without holding any causal relation to it. However this may be, no one can question the great importance of inves-



tigations which aim to determine the cause of a disease which so often takes the form of a destructive epidemic.

Every day we are learning more and more how important it is to have a thorough knowledge of the animal world and man's place in nature. Man is but one among myriads of animals all engaged in the great struggle for existence. His present position and power over the rest of creation, he holds by virtue of his superior intelligence; but the conquest of nature is not completed, in fact, has only begun. A *bacterium*, a prolific worm, or a grasshopper is more than a match for him. His boasted ascendency over nature is largely an idle conceit, and every hour of his life is a demonstration of the fact. He is overwhelmed by those minim specks of life which he so often affects to despise, and which he in his stupidity thinks it unpractical to understand. Consider man's relation to the rest of the animal world. How utterly dependent upon it for the necessities of life, such as food and clothing. He has thus far learned how to obtain from inferior animals only an infinitesimal part of the service they are capable of rendering. There is but one thing that can ever command their complete service, and that is knowledge. A thorough knowledge of the whole realm of life would convert every noxious animal into a harmless, and not improbably into a positively useful creature. It is toward such a knowledge that all the biological sciences, aided by the physical sciences, are aiming. If any further illustrations of the value of such knowledge be required, they may be found in abundance in the facts now known concerning human and animal parasites.

Not very long ago, it was generally supposed that all internal parasitic worms arose by a kind of spontaneous generation within the organs which they occupy.

Thanks to the experimental researches of such men as Professor Leuckart, Von Siebold, and P. J. Van Beneden, we now know that most of these creatures come to us in our food and drink; and this information has proved a mighty weapon of defence, where before ignorance precluded our taking the first step towards protection. Space remains for mentioning only two or three instances; the reader who desires to learn more about the habits, transformations, and transmigrations of these creatures, will find interesting and profitable reading in Van Beneden's "Animal Parasites and Messmates," and in Leuckart's works on human parasites.

There is a thread-worm (*Filaria sanguinis-hominis*) that lives in the human blood, and is generally associated with *Chyluria* and with Lymph-scrotum, or nævoid elephantiasis. These blood-parasites have been found in India, China, Australia, Africa, South America, and England. The question arises how do they find their way into the blood? Dr. Manson of Amoy has taken a very important step towards answering this question, and his results have been confirmed by Dr. Lewis of Calcutta University. Dr. Manson has shown that a mosquito, feeding on the blood of a person afflicted with filariae, draws the embryos along with the blood in which they float, into its stomach; and that there they make considerable advancement towards the mature condition. Dr. Manson thinks that they escape into the water, in which the mosquito dies after laying its eggs, and that they are taken into the system by means of the water that is drunk. If this be the case, as seems probable, nothing further is needed in order to guard against them than to make use of boiled and filtered water.

Such worms generally require, in order to complete their cycle of life, to be transmitted through several